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GOB LEAKAGE IN 8 EAST AT LINGAN COLLIERY

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GOB LEAKAGE IN 8 EAST AT LINGAN COLLIERY

by

A. W. Stokes*

ABSTRACT

The high losses of ventilation air through 8 East's gob provided a good opportunity to perform a detailed ventilation survey in which the pressure profile and air leakages were measured. Some simple assumptions were made about the leakage flows so that "equivalent resistances" of leakage corridors in the gob area could be calculated. These values lead to a better understanding of the leakage of air around the longwall district and of the consolidation and compaction which occurs in the gob.

Some theories are developed to explain the large variation in the resistance of the gob corridors. The future work which will to be conducted to confirm these theories is discussed.

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FUITE DANS LES REMBLAIS À LA GALERIE 8 DE LA HOUILLÈRE LINGAN

par

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RÉSUMÉ

Les pertes d'air élevées dans le remblai de la galerie 8 Est ont fourni une bonne occasion d'effectuer une étude détaillée de la ventilaton au cours de laquelle le profil de pression et les pertes d'air ont été mesurés. De simples hypothèses relatives aux fuites d'air ont été émises de façon à permettre le calcul des "résistances équivalentes" des corridors dans le secteur des remblais où ces fuites surviennent. Ces indices permettent une meilleure compréhension de la façon dont se produisent les fuites d'air dans le district de la pleine section et de la consolidation et du tassement qui qui se produisent dans le remblai.

On élabore actuellement certaines théories visant à expliquer la grande variation de la résistance dans les corridors des remblais. On se penche également sur les travaux qui seront effectués à l'avenir en vue de confirmer ces théories.

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INTRODUCTION

Leakage of air through the gob of an advancing longwall face is proportional to the square root of the pressure difference across it and inversely proportional to the square root of the resistance of the gob. This is understood from the expression:

$$Q = (P/R)^{\frac{1}{2}} \qquad \text{Eq. 1}$$

where Q is the airflow (m^3/s)
P is the pressure difference (N/m^2)
R is the resistance (Ns^2/m^8)

This is a rearrangement of Atkinson's equation for the pressure drop along a roadway:

$$P = (k.s.Q^2)/A^3 \qquad \text{Eq. 2}$$

where k is the friction factor (Ns^2/m^4)
s is rubbing surface (m^2)
A is the cross sectional area (m^2)

so that $$R = (k.s)/A^3 \qquad \text{Eq. 3}$$

Unlike an airway, the volume of air flowing through the gob varies along its longitudinal length. This is caused by a variation in the pressure difference across it, which is a maximum at the outbye end of the district and steadily decreases towards the face. In addition, the resistance of the gob varies throughout due to localised geological conditions and the degree to which the broken rock has been compacted. The overall resistance of the gob could be significantly increased by the use of solid monolithic packing or the application of sealants in the gateroads.

Figure 1 is a simplified plan of a longwall face showing what are generally believed to be the flow paths of the air through the gob of an advancing longwall section. If an airtight gateside pack is not built, large

volumes of air may be lost through the unconsolidated zone in the gob close to the face start line. Leakage of air from the remainder of the intake gateroad is through the broken rock of the gob with flow paths roughly parallel to the face line. Close to the working face air tends to short circuit the intended ventilation route by leaking into the open area of the brushing lip, then either return to the face line or flow parallel to the face in the uncaved area behind the face supports.

In the Sydney Coalfield this leakage is alleviated by the utilisation of connections to adjacent worked out longwall panels (cundy ventilation). Such connections enable the pressure difference across the gob to be greatly reduced or eliminated by the conversion of the return gateroad to a bleeder intake. Return air from the face is then exhausted through the purpose built connection to the up dip adjacent worked out panel.

Early in 1984, 8 East longwall face in Lingan Colliery had advanced in excess of 800 m from the start line. Leakage through the gob had risen so that less than 30 percent of the air entering through the intake fireseal was reaching the face[1].

As part of ongoing investigations into the problem of gob leakage the Cape Breton Coal Research Laboratory (CBCRL), in conjunction with the ventilation staff from the Cape Breton Development Corporation (CBDC), conducted a comprehensive air leakage survey around 8 East longwall on March 31, 1984.

OBJECTIVES OF THE AIR LEAKAGE SURVEY

The high losses of ventilation air through 8 East's gob area provided a good opportunity to make an accurate assessment of the leakage. The large air volume flowing around the district minimised the errors which are inherent in ventilation surveys. By making some assumptions about the airflow patterns through the gob, an equivalent resistance for the gob area may be calculated. The calculation of this equivalent resistance leads to a better understanding of the modes of air leakage and of the compaction and consolidation of the rock which caves after the longwall face has passed. In addition, the equivalent gob resistances together with those calculated for the face line and gateroads can be used as input data for a digital computer ventilation network analysis program which can then be employed to simulate present day conditions and predict future trends. The effects of suggested

solutions to the gob leakage problem may then be given a more quantifiable feasibility evaluation prior to a physical trial.

THE AIR LEAKAGE SURVEY

The survey was performed at a weekend in order to minimise distortion of the readings by regular production shift activities. Maintenance personnel were underground, but no coal production took place. Three teams were used in the survey.

The first team traversed the district moving from the fireseal in the return gateroad up to the face and back along the intake. Every fiftieth arch was marked with luminous spray paint, assigned a number and photographed using a method described elsewhere[2]. A 1 m rod was hung from the sprayed arch providing a reference to enable an accurate assessment of the area of the roadway to be made with a planimeter, an example of which is shown in Figure 2. The photographs also provide a permanent record from which localised conditions (e.g. machinery and obstructions in the roadway) which might have influencd the velocity measurements can be referred to.

The second team, which comprised two men, followed the same route as the first. Their responsibility was to make anemometer traverses at each of the marked arches [i.e. approximately every 45 m (150 ft)] to determine the average air velocity. They also measured the flow of air at three locations on the face and made intermittent checks on the general body methane concentrations. The instuments used were a new, recently calibrated vane type anemometer (AM5000), stopwatch and digital methanometer (CD210).

The third team followed immediately behind the second with a magnehelic gauge, 60 m (200 ft) of tygon tubing and two pitot tubes. They measured the static pressure drop between adjacent stations in the gateroads and arbitrarily chosen points along the face. They continued with their pressure drop measurements outbye of the fireseal in the intake gateroad and up the "Number Four Deep", through the doors in the "Top of Eight" to close the circuit back at the start point in the return gateroad.

ASSUMPTIONS MADE AND THEORY USED IN THE CALCULATION OF GOB RESISTANCE

Figure 3 shows a simplified plan of 8 East longwall with the survey stations used. One of the theoretical "gob corridors" running through the gob area is marked parallel to the line of the face. Its borders are defined

by lines drawn between corresponding survey stations in each of the gateroads. A major assumption made in the analysis of the results from the survey was that air leaking from the intake to return gateroad does so in a line parallel to the face and hence through the corridors. This assumption allows the corridors to be treated as individual roadways. Then by using a rearrangement of equation 1, the measured values of the air leakage through the corridors (the air lost between the adjacent gateroad stations used to define a corridor's boundaries) and the average pressure difference across their ends, their equivalent resistance may be calculated.

The flow path of air leaking through the gob is thought to occur at a slight angle to the face line, as it tends to move in the direction of the low pressure zone, which in this case was towards the outbye end of the return. However, the results of the survey show that the volume of air moving at any location in the intake gateroad was very similar to the flow at the comparable position in the return. This indicates that any deviation of the general flow paths from a line parallel to the working face is certainly small, and for the purposes of this study can be neglected.

In using the method outlined above for calculating the "equivalent gob resistance", the resistance to air leakage offered by the gobside packing in both the intake and return gateroads is included in this value. This "equivalent gob resistance" can be thought to have three components:

(i) the resistance of the gobside pack in the intake gateroad (R_1),

(ii) the resistance of the broken rock caved into the gob (R_2),

(iii) the resistance of the gobside pack in the return gateroad (R_3).

The total "equivalent gob resistance" (R) can be expressed as the sum of these three, thus:

$$R = R_1 + R_2 + R_3 \qquad \text{Eq. 4}$$

The gobside packs in both roadways are made from a combination of hollow and stone filled hardwood packs. The pack alongside the intake also incorporates a wall of stone dust bags intended to present an impermeable barrier to reduce air leakage. Neither pack could be described as dense, since it is easy to find numerous locations where there are visible gaps into the gob. It has been assumed, therefore, that the resistance components R_1 and R_3 are

insignificant compared to the much greater resistance of the gob R_Z and that the calculated gob resistances, R, can be approximated to R_Z.

RESULTS

Tables 1 and 2 contain the airflows measured at the survey stations, the pressure drops between them, the computed values of the roadway resistance and the air power dissipated between adjacent stations. Table 3 gives the volume of air leakage through the gob corridors (values taken from the graph in Figure 4), the average pressure difference across the ends and the calculated "equivalent gob resistances".

Airflow measurements were generally repeated three times at each station, more repetitions were undertaken if variation between individual readings exceeded 5 percent. It was found that the measurements made in the return gateroad were far more repeatable than those in the intake. This was probably due to the conveyor and other large pieces of machinery in the intake which made it difficult to make regular repeatable anemometer traverses. It is impossible to measure the airflow in between and underneath the belts and the space it occupies varies considerably along the length of the roadway making it difficult to make a constant allowance for this inaccessable zone. For this reason, the volume of air leaking into the gob was calculated from the airflow profile in the return (see Figure 4).

The airflow profile in Figure 4 shows 35 m^3/s of air in the gateroad close to the face start line which falls quickly in the first 500 m losing some 14 m^3/s as leakage through the gob (40 percent of the air). From 500 m to 800 m inbye the face start line the amount of gob leakage reduces considerably increasing again from 800 m inbye to the coalface. The increased leakage close behind the coalface is probably due to the unconsolidated nature of the gob in this area. It is not uncommon to see open areas of gob immediately behind the face roof supports through which air can short circuit the face line to the return gateroad.

The closure error of the pressure survey was 17 percent. A 10 percent error for such surveys is considered acceptable, the higher error for this survey was probably due to the large number of pressure measurements made of pressure drops of 5 Pa and less. Figure 5 shows the pressure profile

around 8 East, the differential pressure drop across the ends of the gob corridors was taken directly from this.

The values taken from the graphs in Figures 4 and 5 were used to calculate the resistance of the gob corridors. Figure 6 shows these calculated values plotted against the inbye distance of the corridor from the face start line.

This shows quite clearly how the "equivalent resistance" of the gob varies along its longitudinal length. Close to the face start line the resistance of the gob corridors are fairly constant with values between 55 and 65 $N.s^2/m^8$. These increase in value rapidly from 300 m inbye to a maximum value of close to 250 $N.s^2/m^8$ 500 m inbye. This value remains stable for the next 150 m followed by a rapid decrease immediately behind the face line. The variation in the gob resistance may be explained by any of a number of hypotheses:

(i) Localised geological abnormalities; e.g. sandstone channels which may cause the rocks which cave into the gob to be very large, making a porous gob area with a low resistance.

(ii) The main deeps shield (and/or fire shield) pillar behind the face start line probably has a significant effect on the caving of the rocks into the gob area. The pillar produces a cantilever of rock extending out above the gob area, thus preventing complete compaction and consolidation. This effect gradually diminishes as the face moves away until complete compaction occurs (as indicated by the increasing gob resistance).

(iii) Some authorities claim the existence of a rear abutment which follows an advancing longwall face. Extensive monitoring of the loading of the roadside packs behind advancing longwall faces in the Sydney Coalfield by Cain[2] has failed to confirm the existence of such a rear rebutment. However, it is possible that it may only occur in the gob area and has, therefore, remained undetected.

Of the three most likely explanations outlined above, if the mining layout (ii) is the overriding factor which causes the observed variations in gob resistance, it should be possible to repeat the air leakage survey around 8 East sometime in the future when the face has advanced further inbye. Repeating the calculations of the gob resistances should show

that the trailing section close to the face seen in Figure 6 moves with the face leaving a plateau from 500 m inbye to within approximately 200 m of the face line. The resistance of the gob corridors close to the face could be expected to remain low as there will always be loose unconsolidated rock there.

If (i) is the significant factor then a repetition of this survey on another longwall in a different area of Lingan Mine or the Sydney Coalfield should reveal varying values for gob resistance associated with known geological structures.

Explanation number (iii) requires a repeat survey of 8 East when the wall has advanced further and an instrument capable of measuring vertical load in the gob has been developed.

All of the further studies suggested are currently being planned and should be completed within the next year.

CONCLUSIONS

The air leakage survey provided quantitative data about the volume of air leaking from 8 East intake gateroad into the gob area. Perhaps more importantly it provided the base data from which the resistance of the so called gob corridors could be calculated. This in turn highlights the areas in which remedial measures to reduce the leakage should be concentrated and gives a better understanding of the resistance to the passage of air offered by the rocks in the gob. Further studies are required in order that the exact contribution of all the factors which influence the gob compaction can be determined.

ACKNOWLEDGEMENT

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- CBDC Ventilation Staff
- David Genter, Senior Ventilation Engineer (CBDC)
- Gary Corbett (CBCRL)

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1. Genter, D. - Private Communications; March 1984.
2. Aston, T. and Cain, P. "Strata control investigations in the Sydney Coalfield"; CANMET Division Report ERP/CRL 83-12(IR); June 1983.

Table 1 - Measured and calculated values for the intake gateroad

Station Number	Distance inbye (ft)	Airflow (m^2)	Pressure Drop (m^2)	Equivalent Resistance (gauls)	Air Power (WATTS)
1	250	34.70	9.96	0.008275	345.7
2	375	32.80	6.22	0.005789	204.2
3	525	30.75	6.22	0.006586	191.4
4	675	28.98	7.47	0.008898	216.5
5	825	27.24	6.22	0.008393	169.6
6	975	25.60	6.22	0.009502	159.4
7	1125	24.18	4.98	0.008521	120.4
8	1275	22.92	3.73	0.007113	85.6
9	1425	21.85	7.47	0.015653	163.2
10	1575	20.98	4.98	0.011319	104.5
11	1725	20.32	4.98	0.012066	101.2
12	1875	19.83	4.98	0.012669	98.7
13	2025	19.30	4.98	0.013375	96.1
14	2175	18.70	4.98	0.014247	93.1
15	2325	18.05	4.98	0.015291	89.9
16	2475	17.67	9.96	0.031912	176.0
17	2625	16.10	7.47	0.028830	120.3

Table 2 - Measured and calculated values for the return gateroad

Station Number	Distance inbye (ft)	Airflow (m^2)	Pressure Drop (m^2)	Equivalent Resistance (gauls)	Air Power (WATTS)
1	250	34.70	224.19	0.186190	7779.3
2	375	32.80	199.28	0.185232	6536.3
3	525	30.75	124.55	0.131721	3829.9
4	675	28.98	74.73	0.088981	2165.6
5	825	27.24	124.55	0.167853	3392.7
6	975	25.60	112.09	0.171036	2869.5
7	1125	24.18	112.09	0.191714	2710.3
8	1275	22.92	112.09	0.213372	2569.1
9	1425	21.85	99.64	0.208704	2177.1
10	1575	20.98	49.82	0.113186	1045.2
11	1725	20.32	74.73	0.180987	1518.5
12	1875	19.83	74.73	0.190042	1481.8
13	2025	19.30	74.73	0.200623	1442.2
14	2175	18.70	62.27	0.178086	1164.5
15	2325	18.05	49.82	0.152915	999.2
16	2475	17.67	87.18	0.279234	1540.5
17	2625	16.10	74.73	0.288299	1203.1

Table 3 - Measured and calculated values for the gob corridors

Station Number	Distance inbye (ft)	Airflow (m^3/s)	Pressure Drop (Pa)	Equivalent Resistance (gauls)	Air Power (WATTS)
1	250	2.15	276.50	59.80	594.4
2	375	2.00	254.08	63.52	508.1
3	525	1.90	232.90	64.51	442.5
4	675	1.80	212.98	65.73	383.3
5	825	1.70	194.29	67.23	330.3
6	975	1.55	178.10	74.13	276.0
7	1125	1.30	161.91	95.81	210.4
8	1275	1.20	144.47	100.30	173.3
9	1425	1.05	133.26	120.87	139.9
10	1575	0.85	120.81	167.20	102.6
11	1725	0.65	108.35	256.47	70.4
12	1875	0.65	95.90	266.39	62.3
13	2025	0.60	84.69	235.26	50.8
14	2175	0.55	70.99	234.68	39.0
15	2325	0.60	58.54	162.60	35.1
16	2475	0.75	44.84	79.71	33.6
17	2625	1.25	31.13	19.93	38.9

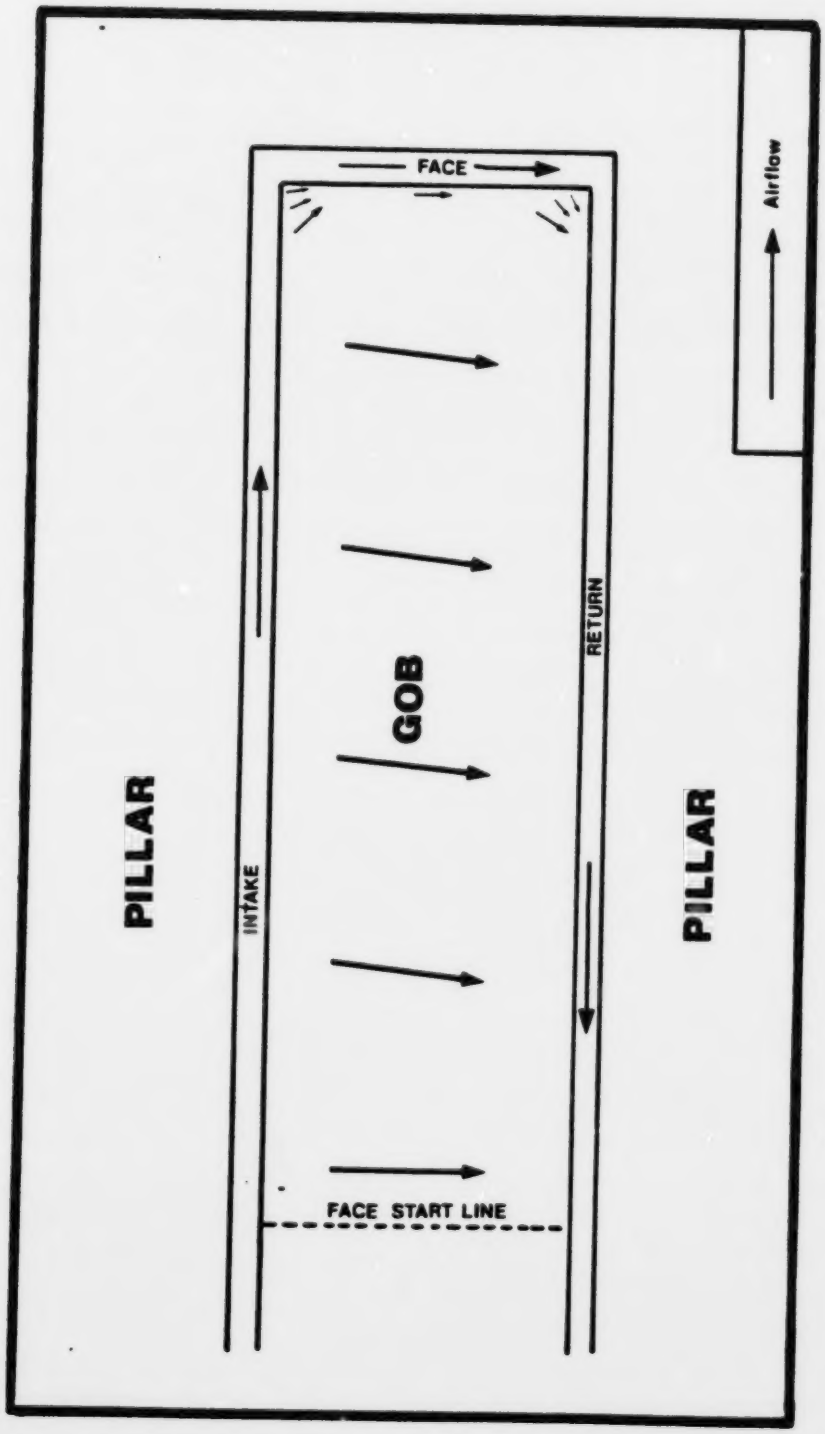

Figure 1 - Air leakages around a longwall panel

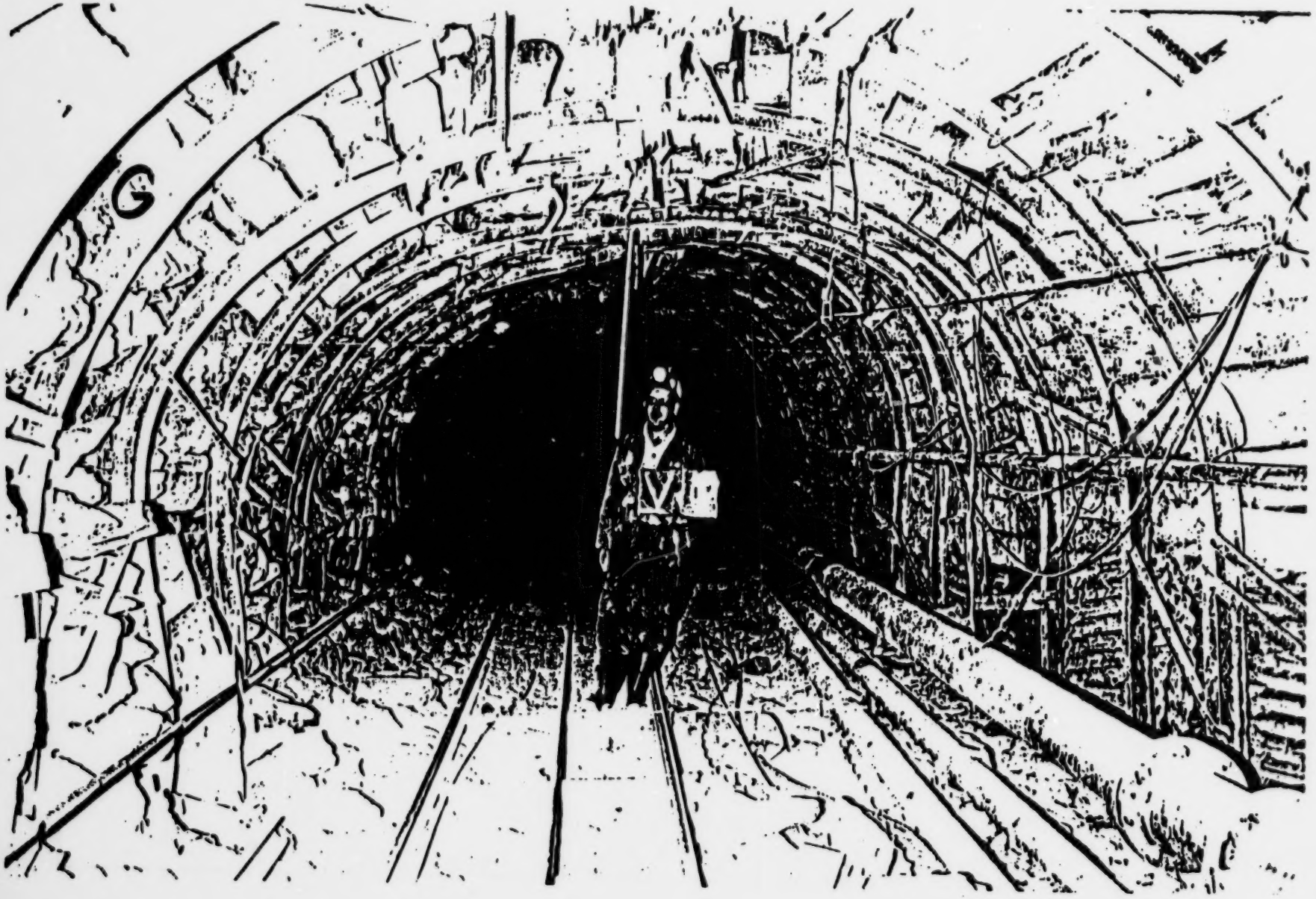

Figure 2 - Photograph from 8 East air leakage survey

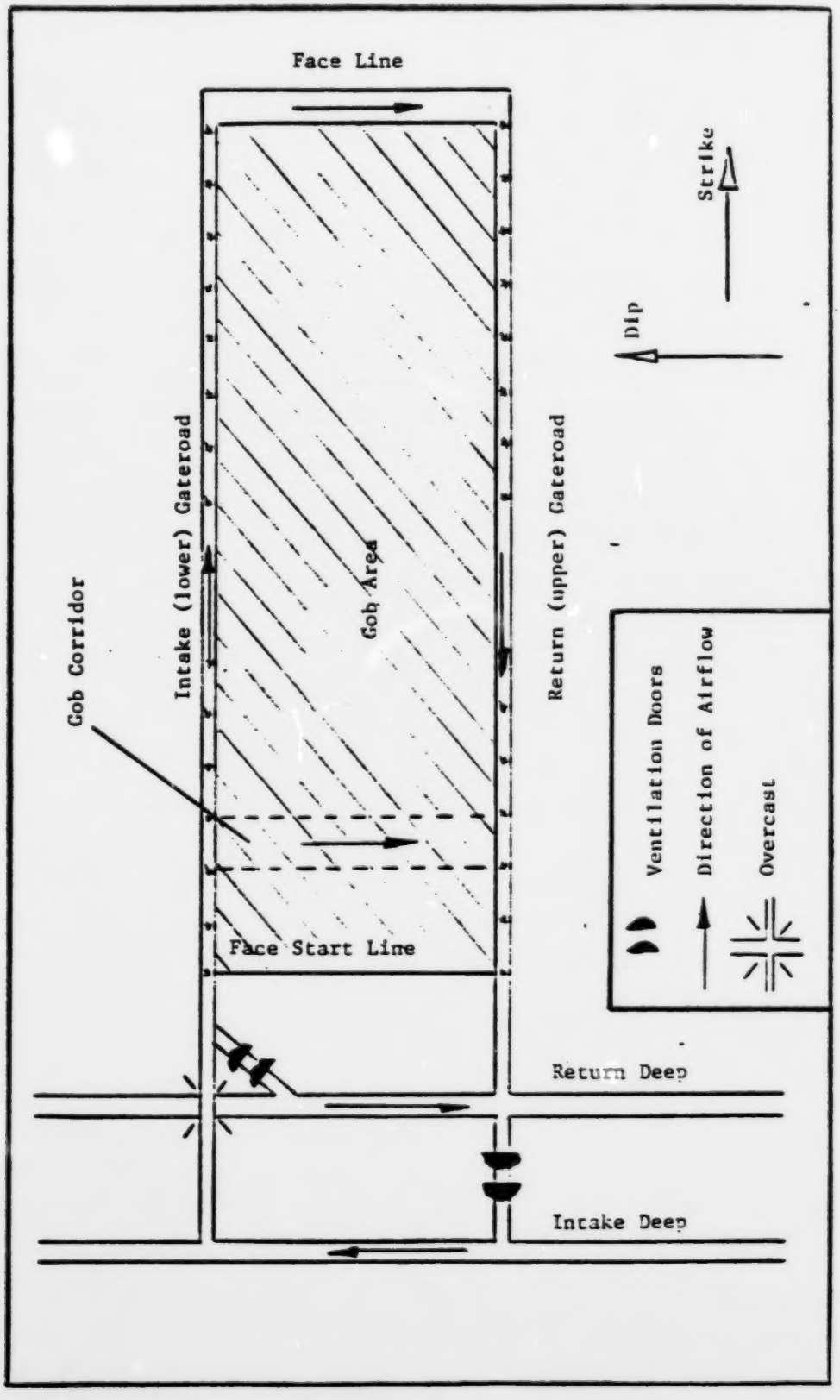

Figure 3 - 8 East survey stations and gob leakage corridors

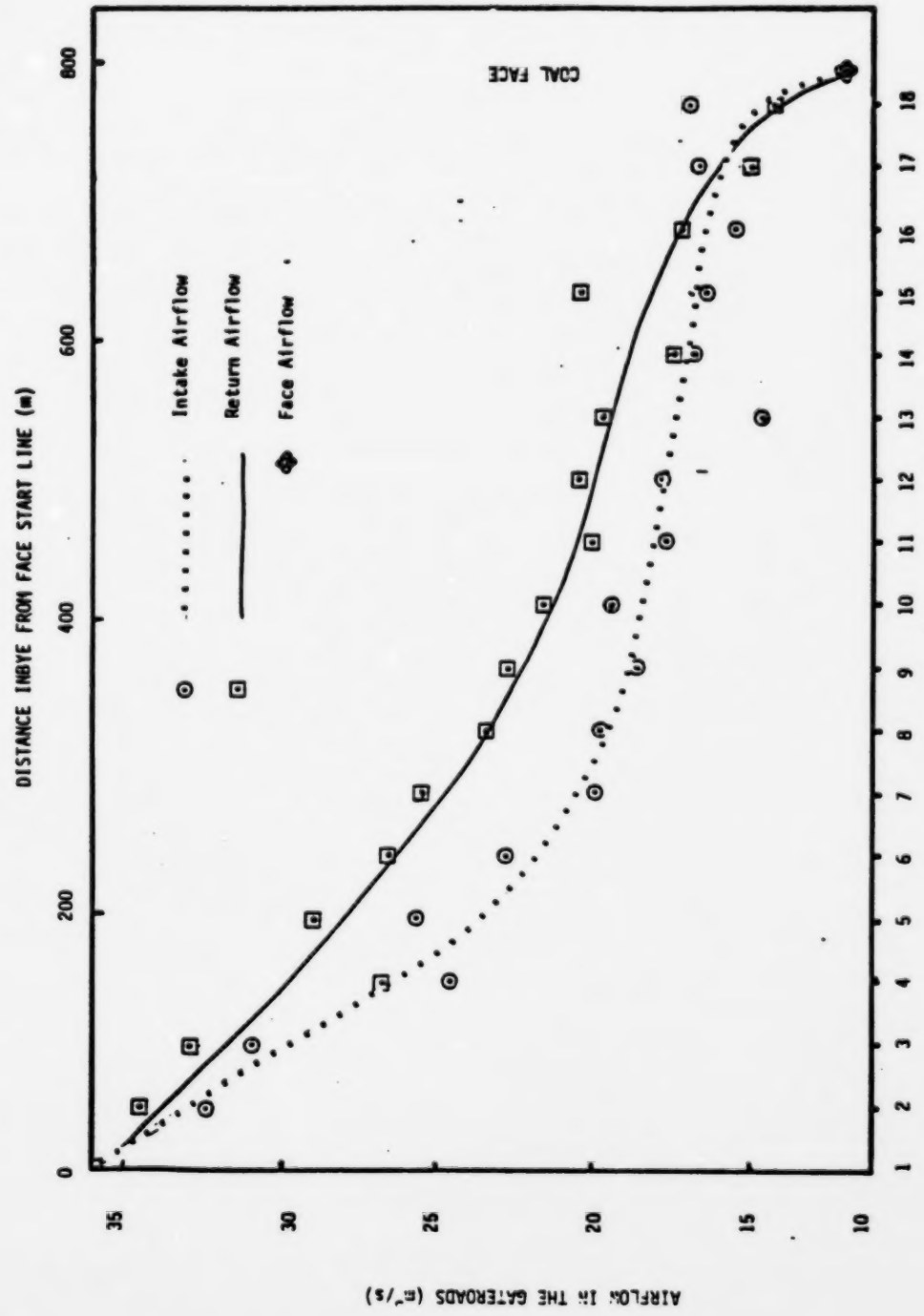

Figure 4 - Airflow in the gateroads versus distance from the face start line

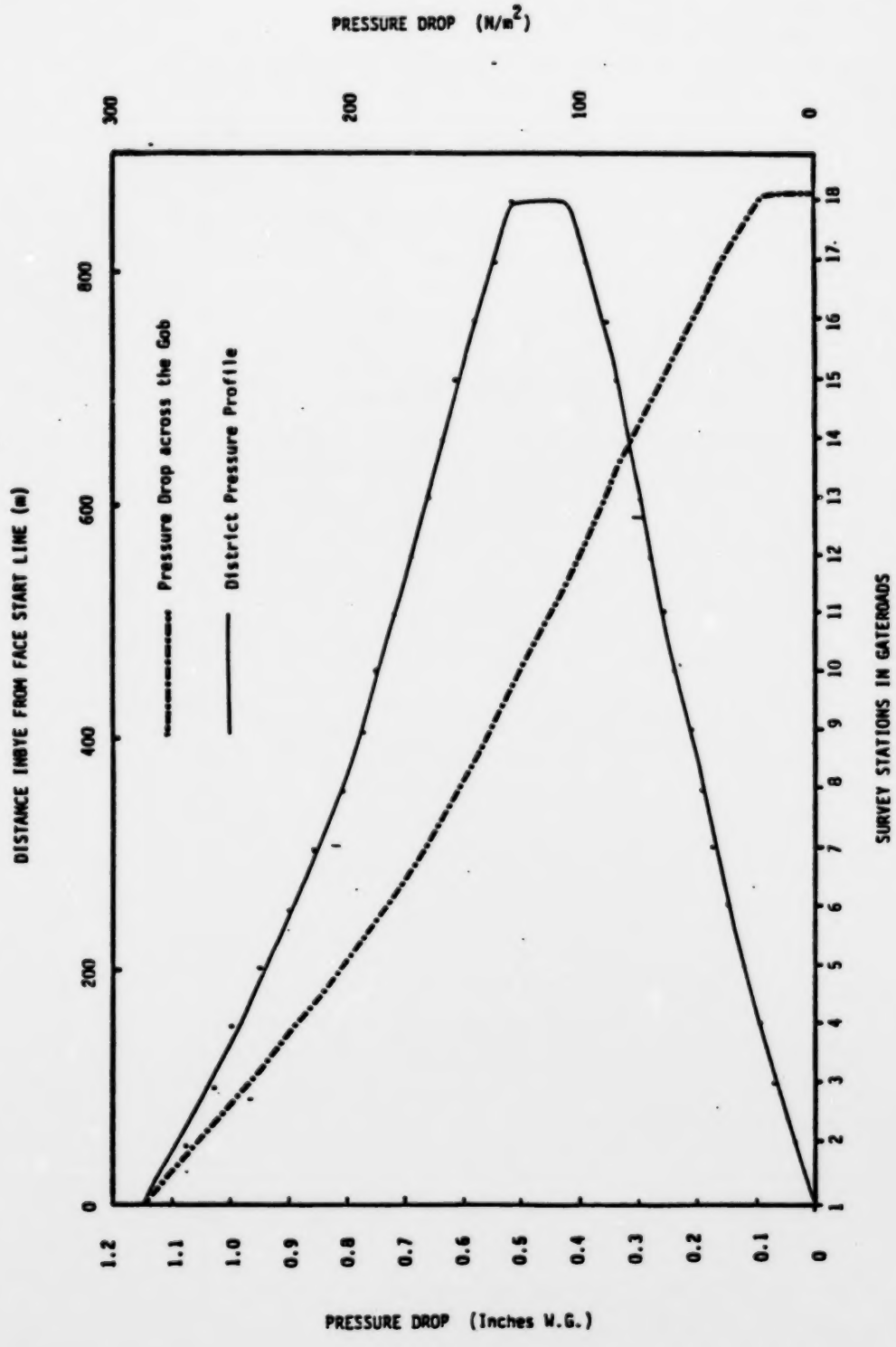

Figure 5 - Pressure profile around 8 East district and pressure difference across the gob

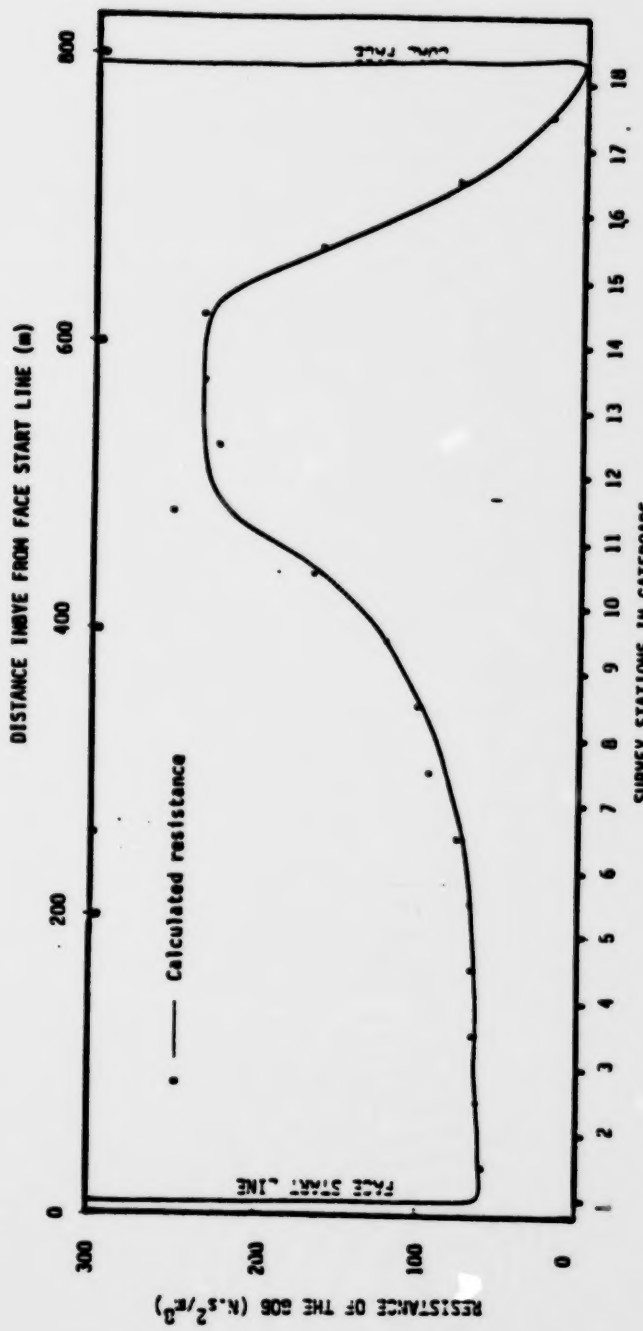

Figure 6 - Resistance of the gob versus distance from the start line